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ARTICLE

The cultural pages of comics: cross-cultural variation in page layouts

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ABSTRACT

Page layouts are a salient feature of comics, which have only recently begun to be studied using empirical methods. This preliminary study uses corpus analysis to investigate the properties of page layouts in comics from Europe (Sweden, France), Asia (Japan, Hong Kong), and America (Mainstream, Indy genres). Pages from Asian books used more vertical segments and bleeding panels, while European and American Indy pages used more horizontal staggering. Pages from American mainstream comics used widescreen panels spanning a whole row, and more variable distances between panels (separation, overlap). These results suggest that pages from different types of comics have different systematic characteristics, which can be studied by empirical methods.

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Introduction

As the first thing a reader engages with when viewing a comic page, the page layout is a primary and highly salient characteristic. Layout is also a page's 'external compositional structure' (ECS): it is the organisational structure 'external' to panels (i.e. panels relative to each other), rather than 'internal' to panels (i.e. the composition of elements within an image) (Cohn 2013a, 2013b). This salience has been especially apparent in layouts from different cultures, which have been said to vary in their features. However, although a growing number of corpus analyses have begun to investigate the properties of the visual languages used in comics (Forceville 2011; Abbott and Forceville 2011; Cohn and Ehly 2016; Cohn, Taylor-Weiner, and Grossman 2012), including page layout (Pederson and Cohn 2016), no empirical, data-driven research has yet reported cross-cultural variation in page layouts. Thus, we aim to begin such analyses of ECS using a cross-cultural corpus study of 60 comics from three continents.

Early theoretical work on page layout emphasised the links between ECS and a sequence's meaning (Barber 2002; Caldwell 2012; Postema 2013). Such a focus underlies theories emphasising the dynamic relations between linear panel-to-panel relations and page compositions (Bateman and Wildfeuer 2014; Fresnault-Deruelle 1976; Groensteen 2007; Molotiu 2012). Other work has characterised layouts as using conventional or regular features without meaningful qualities, and those where meaning is conveyed by

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the layouts themselves (Groensteen 2007; Peeters [1991] 1998). Such categories highlight the functional uses of layout in relation to a narrative.

Although a reader accesses the sequential content of a visual narrative via its layout, ECS is ultimately different from narrative and meaning (Cohn 2014). Granted, ECS and meaning can coordinate – such as stacked panels successively showing someone falling such that their vertical motion is aligned with the verticality of the panel reading (Cohn 2014). However, such examples reflect the *interfacing* of ECS and meaning, not their inseparability. So long as the order of reading panels remains constant, many panels can be rearranged into several layouts without altering the sequential meaning. A basic six-panel sequence could appear horizontally, vertically, or as grids, all without changing the meaning. Indeed, eye-tracking research has shown that altering page layouts does not necessarily impact the comprehension of the sequential content (Foulsham, Wybrow, and Cohn 2016; Omori, Ishii, and Kurata 2004). In addition, behavioural experiments have demonstrated that comic readers follow systematic preferences for the reading order of panels in page layouts, even in the absence of imagistic content (Cohn 2013a; Cohn and Campbell 2015). Such empirical findings reinforce the independence of layout and content.

ECS is also separate from meaning because specific features of page layouts can be characterised in isolation for their purely spatial properties, without reference to panel content (Cohn 2013a, 2013b, Bateman et al. 2016; Witek 2009). The default layout of comic pages appears to be the *grid* (as in Figure 1(a)), which arranges panels into rows and columns. These panels are typically ordered in a 'Z-path' similar to text: left-to-right and down for American and European comics, but right-to-left for many Asian comics. A *pure grid* maintains contiguous borders between all adjacent panels, while misalignments between this contiguity can result in *staggered* panels. *Horizontal staggering* (Figure 1(c)) maintains the contiguity between horizontal panels (a row), while

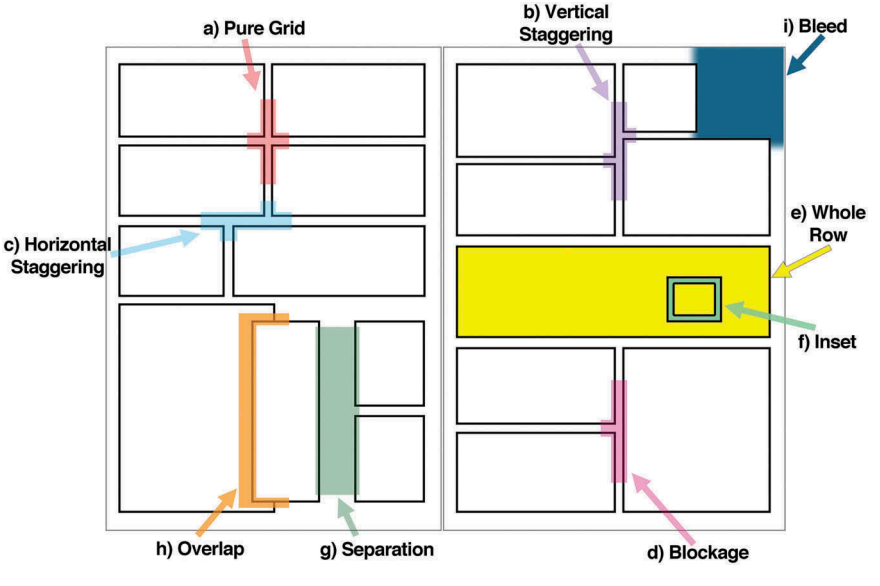

Figure 1. Schematised features of panel arrangements in page layouts.

the vertical borders become discontinuous. Misalignment of the horizontal borders, with contiguity between vertical borders (columns) results in *vertical staggering* (Figure 1(b)). When vertically stacked panels occupy the whole space next to a single panel, it creates *blockage* (Figure 1(d)). *Inset* panels (Figure 1(f)) place one subordinate panel within another *dominant* panel.

Other features of layout go beyond their arrangements. The space between panels – the 'gutter' – can be varied from the 'normal' width used by each artist's idiolect. *Separation* is created by sizeable gaps between panels (Figure 1(g)), while panels on top of each other create an *overlap* (Figure 1(h)). Panels can also vary in shape (square, rectangular, quadrilateral, circular, irregular, etc.) and in what type of border they use. For example, departing from a standard line for a border, some panels might be *borderless*, or use a *bleed* (Figure 1(i)) – a borderless panel that extends to the edge of the printed page.

While the standard navigation of page layouts uses a Z-path, these various ECS features may push a reader to alternate routes. For example, in blockage (Figure 1(d)), when starting at the top left panel, a person could either move to the right (Z-path) and then backtrack to the lower panel, or they could move vertically, before moving right. Experimental participants respond that moving vertically in a blockage layout is the preferred path, rather than moving horizontally to the adjacent panel, thus flouting the Z-path (Cohn 2013a; Cohn and Campbell 2015). Such navigation appears to maintain a hierarchic organisation, whereby panels are organised into vertically and horizontally embedded groupings (Cohn 2013a; Tanaka et al. 2007; Bateman et al. 2016).

For example, Figure 2 illustrates the hierarchic structure of a page from Gene Yang's *Boxers*. This page features three rows, reflected in the three horizontal constituents. These rows are stacked, embedded within a larger vertical constituent, which is also the maximal level (the canvas). Finally, the last row also features a blockage arrangement, whereby the final two panels form a column – again reflected in an embedded vertical

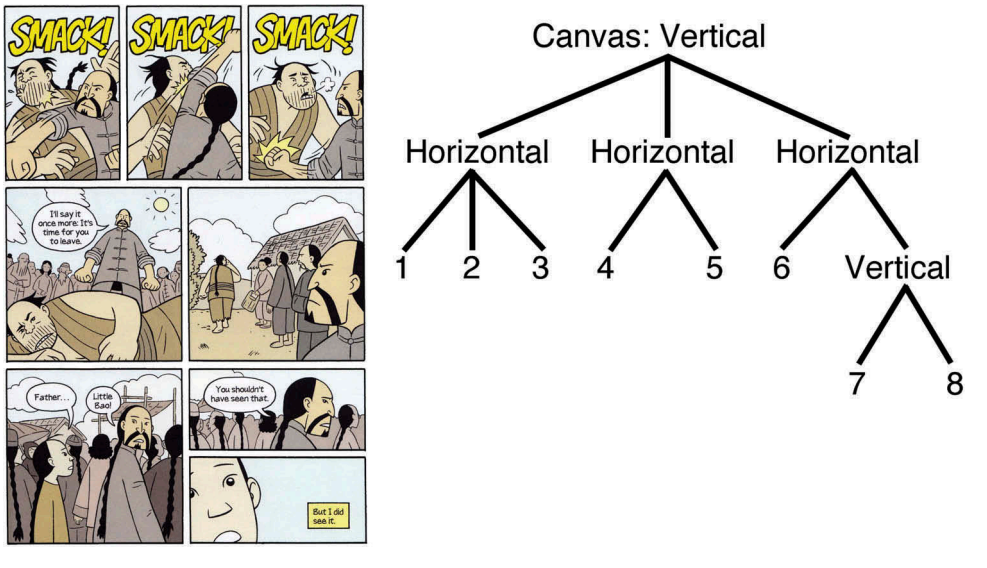

Figure 2. Hierarchic structure for a page in *Boxers* by Yang (2013, 13, First Second).

constituent. Hierarchic structures such as these are implied for page layouts both through psychological experimentation (Cohn 2013a; Cohn and Campbell 2015), and through automatic parsing of corpus data through computational algorithms (Cao, Chan, and Lau 2012; Tanaka et al. 2007).

Thus far, the only published corpus analysis investigating the properties of page layouts from different comics looked at change in structure over 80 years of American superhero comics (Pederson and Cohn 2016). Overall, older comics used more grids along with variable traits of ECS (odd panel shapes, etc.), and recent works have changed to be more systematic, while also using the whole page more decoratively (with variable non-grid features). This finding manifested in several ways. First, the directions between panels indicated a move away from relying on the Z-path (right, down-left, right), and towards vertical, straight down relations. In addition, horizontal staggering decreased from its prevalent use in older comics, with an increase in the use of whole rows in contemporary comics. Gutter width also grew more variable, with more separation and overlap, as did panels without borders and bleeding past the edge of the page. These findings were taken to indicate that page layouts in American superhero comics have grown both more systematic and decorative over time, shifting towards a view of the page as a whole 'canvas'.

While this study provided initial observations about the properties of page layout in American superhero comics, it raised additional questions. For example, given the influx of Japanese manga into the United States' comic industry in the 1990s, might some of these changes over time reflect influence from manga? This type of attribution can only be possible knowing the traits of actual manga. And, what are the structures found in page layouts across comics from various cultures or genres, and do they differ from each other in systematic ways?

One factor that may motivate page layouts to differ across cultures is the orientation of a writing system. This is overtly noticeable in that most comics originating from America and Europe use a left-to-right Z-path, while those from Asia use a right-to-left Z-path. Although page layouts may depart from the Z-path inherited from horizontally oriented writing systems, the Z-path still forms the foundation of external compositional structure (Cohn 2013a; Cohn and Campbell 2015). Indeed, gridded panel arrangements are read with similar eye-movements to text (Foulsham, Wybrow, and Cohn 2016), and deviations from a Z-path are treated with systematic strategies (Cohn 2013a; Cohn and Campbell 2015).

In addition, several studies have found that the orientation of a writing system – left-to-right versus right-to-left – can influence various aspects of perception. Left-to-right writing systems bias participants towards left-to-right orders for depicting temporal relationships (Chan and Bergen 2005; Tversky, Kugelmass, and Winter 1991), for assigning semantic agency to objects (Dobel, Diesendruck, and Bölte 2007; Maass and Russo 2003), for determining the temporal order of images (Fuhrman and Boroditsky 2010), for perceptually scanning arrays (Padakannaya et al. 2002), and for drawing pictures (Vaid et al. 2002), while the reverse is true of right-to-left systems. Thus, directions of writing systems influence aspects of cognition beyond the reading of just text.

While it is a basic fact that overall orientation of a page's reading is maintained for left-to-right (American, European comics) versus right-to-left comics (Japan, Hong

Kong), other influences of writing systems on page layouts remain unaddressed. For example, beyond lateral directions, writing systems also differ in terms of horizontal reading (Z-path) versus vertical reading (N-path). We may hypothesise that Western comics (American, Europe, etc.) will maintain more horizontally oriented layouts than those from countries where writing may have a vertical direction (for example, Japan – which allows both horizontal and vertical directions). Such a difference may manifest itself in more vertical arrangements of panels, as in columns used in blockage.

With these questions and precedents, we therefore carried out a study of page layouts from six different types of comics from three continents (Asia, America, Europe). We reasoned that patterned differences between cultures' page structures would imply that the graphic systems used in 'comics' are not uniform, but rather indicative of many 'visual languages' with their unique properties (Cohn 2013b), as suggested by a growing literature (Cohn and Ehly 2016; Cohn, Taylor-Weiner, and Grossman 2012; Forceville 2011). Insofar as such structures reflect information stored in the minds of creators, such differences would imply variation in mental patterns of authors from different cultures, and thereby habituated by their readers.

We acknowledge upfront that any conclusions reached by our study are of course limited by our selected corpus, and thus consider this a preliminary work empirically exploring a variety of different cultures' structures. Such a study thus can provide the groundwork for further, more extensive and nuanced corpus analyses, and hopefully can sponsor other researchers to engage in a similar, data-driven methodology.

Methods

Materials

Our corpus consisted of 60 comics, ten each from six different types of comics. As listed in Table 1, we chose two types of comics from three regions of the world: the United States, Europe, and Asia. Within these we analysed books from the United States (both mainstream and independent genres), France, Sweden, Japan (shonen manga), and Hong Kong. Our selection of books was limited in that it largely used convenience sampling, and we analysed the works that were available to us. In many cases, it was impossible to arrive at a homogeneous sample that also sufficiently matched all other groups in terms of genre, publication date, and the myriad other factors that comics may vary. We therefore chose to use a broad selection of works that satisfied our primary criteria, with the thinking that future works can aim toward further nuanced distinctions. Our selection of ten books per group is consistent with those used in other

Table 1. Basic page and panel information coded in the corpus.

Country	Quantity	Total Pages	Total panels	Panels per page
Sweden	10	246	1476	6.74
France	10	265	1618	6.21
Hong Kong	10	255	1291	5.04
Japan	10	178	925	5.21
American Indy	10	250	1304	5.23
American Mainstream	10	214	986	4.54
Grand Total	60	1408	7600	5.49

corpus studies of comics (Cohn and Ehly 2016; Cohn, Taylor-Weiner, and Grossman 2012; Pratha, Avunjian, and Cohn 2016) and exceeds most other empirical studies of comics (e.g. Forceville 2005; Forceville 2011; Juricevic 2017). All data were gathered specifically for this study, except for those from Mainstream American comics, which were taken from previous work (Pederson and Cohn 2016), and selected to match our other cross-cultural data based on nearest dates of publication. A listing of all Works Analyzed is provided in the Appendix.

Comics were coded panel by panel according to criteria in the Areas of Analysis. Books were analysed in their entirety, up to a single chapter in a trade paperback, up to the first 25 pages, or up to roughly 150 panels (completing a whole page), whichever came first. Across all comics, this amounted to 1408 pages with 7600 panels. All coded data belong to the Visual Language Research Corpus (VLRC: http://www.visuallanguagelab.com/vlrc).

Areas of analysis

Our analysis of ECS coded each panel on a page both for attributes they held independently (e.g. a panel's shape) and in relation to surrounding panels (e.g. the border shared between two panels). Following prior work (Pederson and Cohn 2016), we focused on four fields of ECS: *directionality, panel arrangements, gutter space* and *panel shape*. We also analysed data related to the number of pages in a book, the number of panels per book, and the number of panels per page.

Directionality

We first analysed the spatial relationship between panels on a page by approximating the centre-point of a panel in relation to the centre-point of the narratively preceding panel. We then coded the vector between these points in terms of one of eight directionalities (right, left, up, down, and in-between). For example, the standard Z-path for a 2 × 2 grid read in a left-to-right and down Z-path order uses directions of right, down-left, right (as seen in Figure 1(a)). Since directionality was coded in terms of one panel in relation to a prior panel, a label of *first panel* with no directionality was coded for the starting panel of a page. Because books in our corpus used different basic directions (left-to-right for Western books, right-to-left for some Asian books), our final analysis averaged across these surface directions to create 'standardised' directions of *lateral* (left, right), down-diagonal (down-left, down-right), and *up-diagonal* (up-left, up-right) in addition to *down* and *up*.

Panel arrangements

Analysis of panel arrangements identified the spatial orientation of panels in relation to other panels on a page. The most basic and iconic of these arrangements is a ***pure grid*** (Figure 1(a)), where panels are arranged into rows and columns where the horizontal and vertical borders of all panels are aligned. Deviations from the grid included *vertical staggering* (Figure 1(b)) and *horizontal staggering* (Figure 1(c)) where the panel borders are not contiguous with each other, while otherwise maintaining a basic grid. Arrangements using *blockage* (Figure 1(d)) were identified if panels were stacked into a vertical column adjacent to a single longer panel. Other characteristics of ECS simply

arise from basic orientations on a page. For example, a *whole row* (Figure 1(e)) panel extends fully from the left to the right side of a page, while a *whole column* extends from top to bottom. Finally, *insets* (Figure 1(f)) are panels embedded inside of another, *dominant* (Figure 1(e)) panel.

Gutter space

Besides arrangements of panels, the distance between panels, i.e. the 'gutter', can also be modulated. We identified a *normal gutter* width as the standard space between two panels that grouped them together, as determined by the normalised tendencies of each author. A *separation* (Figure 1(g)) of the gutter space was identified if panels were further apart than this 'standard' distance (e.g. Cohn and Campbell 2015; Cohn 2013a). *No gutter* was coded for situations where only a line separated panels, while an *overlap* (Figure 1(h)) occurred when one panel crossed over the space of another panel.

Panel shapes

Our analysis of panel shapes included both standard shapes, such as squares or rectangles or other quadrilaterals, and less expected shapes such as circles, triangles, irregular shapes (panels without any distinct geometric shape), and diagonals (as if diagonally spanning from opposite corners of a square). We also assessed the presence or absence of panel borders. *Borderless panels* were images with no depicted frame around them, while *bleeding panels* (Figure 1(i)) were specific borderless panels where image content extended beyond the edge of the page.

Data analysis

Four trained coders analysed the comics panel by panel for each area of analysis described above. All coders were trained in the areas under analysis and began coding for the corpus only after surpassing a threshold of 85% agreement to each other and 'answer keys' with practice materials. For each book, we calculated the mean proportion of each area under analysis out of the total number of panels. We used Analysis of Variance (ANOVAs) to compare means between books, setting Type (our six book types) as a between-groups factor, with comparisons within an analysis type (e.g. directionality) as within-groups factor(s). We used targeted pairwise comparisons for follow up analyses.

Finally, in order to assess similarities and differences between our books in terms of recognisable groupings, we used a *k*-means clustering analysis. This analysis partitioned individual books into similarly structured clusters on the basis of specified features – here, all features of directionality, arrangement, gutter size and panel shape. These data were used to partition the books into clusters nearest to a prototypical mean, and yielded values to describe the distance from those means. We used two *k*-means analyses, setting the number of clusters at three (continents analysed) and six (groups analysed).

Results

Basic page properties

Overall, the average number of panels per page differed between our analysed groups, $F(5,54) = 2.98$, $p < 0.05$. As listed in Table 1, books from Europe (French: 6.2 panels per page, Swedish: 6.7) used more panels per page than those from America (Indy: 5.2, Mainstream: 4.5) and Asia (Japan: 5.03, Hong Kong: 5.2). However, statistically, Swedish used more panels than all types except French comics (all $p < 0.05$), and French comics trended in panels being used more than Hong Kong comics ($p = 0.084$). American and Asian books did not differ statistically.

Directionality

Our overall analysis of the directions between panels found main effects of Directionality and Type (all Fs > 3.4, all ps < 0.01), and an interaction between them, $F(15,162) = 9.8$, $p < 0.001$. This implied that comics of different types differed in their proportions of directions between panels. Across all books, lateral directions (left or right) between panels appeared more than any other direction, implying layouts dominated by rows of panels (see Figure 3). Up-diagonal relations were used the least of all directions, at less than 1% in all books (appearing, for example, in the relation from a panel at the bottom of a blockage column to the next panel). The rates of straight downward relations and down-diagonals varied greatly between different types of comics. On their own, each direction differed significantly between types of comics (all Fs > 7.6, all ps < 0.001).

A standard Z-path is most indicated by the combination of lateral and down-diagonal directions. Lateral directions (left, right) were used more in Swedish comics than all other comics (all ps < 0.05). Hong Kong manhua and American Mainstream comics used the least lateral relations, significantly less than French or American Indy comics (all ps < 0.05). Manhua also used fewer lateral relations than Japanese manga

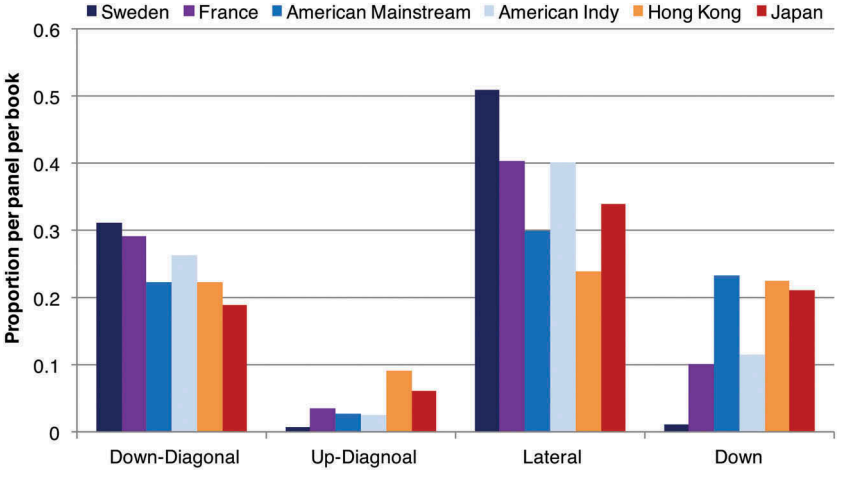

Figure 3. Panel-to-panel relational directions in different types of comic pages.

($p < 0.05$). The intermediate rates of lateral relations between French, Japanese, and American Indy comics did not differ.

Down-diagonal directions were used more in Swedish and French books than all other comics (all ps < 0.05), except for the intermediate amounts in American Indy comics, which did not differ from the French books. American Indy comics also used more down-diagonal relations than Japanese manga ($p < 0.005$), but otherwise no differences were found between them, manga, Hong Kong manhua, or American Mainstream comics.

Downward motions were used more in Hong Kong manhua, Japanese manga and American Mainstream comics than all other books (all ps < 0.05), but did not differ from each other. Swedish comics used fewer downward relations than all other comics (all ps < 0.005).

Finally, up-diagonal directions were used the most in Asian books, with Hong Kong manhua using more than all other books (all ps < 0.05), followed by Japanese manga, which used more than all but manhua (all ps < 0.05), and trended more than French *bande dessinée* ($p = 0.084$). The intermediate amount in French books also used more than Swedish comics ($p = 0.054$), but did not differ from American books of either type.

Panel arrangements

Pure grids were by and large the most used arrangement, although they differed between types of comics, $F(5,54) = 3.2$, $p < 0.05$. As in Figure 4, more pure grids were found in Mainstream American comics than any other type (all ps < 0.05), except Swedish comics. Swedish comics also used significantly more grids than French books ($p < 0.05$), which used pure grids the least. The intermediate rates of grids used by other books did not differ statistically.

A comparison of non-pure grid panel arrangements (blockage, vertical staggering, horizontal staggering) across our corpus showed the main effects of both Arrangements, $F(2,108) = = 57.4$, $p < 0.001$, and Type, $F(5,54) = 2.7$, $p < 0.05$, as well as an interaction between them, $F(10,108) = 8.5$, $p < 0.001$. This suggested that our analysed types of

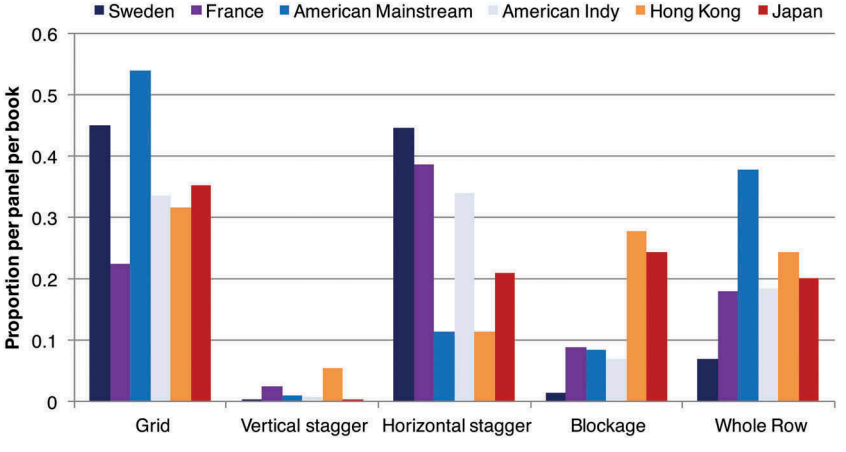

Figure 4. Types of panel arrangements used in different types of comic pages.

comics use various types of panel arrangements in differing proportions. We followed these analyses by examining each of the arrangements across cultures.

Significant differences arose in the rates of using horizontal and vertical staggers (all Fs > 3.2, $p < 0.05$). Horizontal staggers were used more in French, Swedish and American Indy comics than those from Hong Kong or Japan, or Mainstream American comics (all ps < 0.05). Vertical staggering was used more in Hong Kong manhua (6%) than all other types of books (all ps < 0.058). French *bande dessinée* (2%) used this more than other types of books (<1%) but these differences were not statistically significant.

Blockage differed across the cultures $F(5,54) = 12.04$, $p < 0.001$, motivated by significantly more frequent use in Hong Kong manhua and Japanese manga than all European and American comics (all ps < 0.05). American and European books did not differ from each other except for French books trending to use more blockage than Swedish books ($p = 0.087$).

The use of panels that spanned whole columns (vertically from top to bottom of the page) was greatest for Hong Kong manhua (6%) and American Mainstream comics (2%) and below 1% for all others, but did not differ across types of comics ($p = 0.154$). However, whole rows spanning lengthwise across a page (right to left borders) did differ, $F(5,54) = 7.5$, $p < 0.001$. American superhero comics used more whole rows than any other comics (all ps < 0.05). Swedish comics used fewer whole rows than any other comic (all ps < 0.05).

Whole pages (i.e. 'splash pages') also differed across books, $F(5,54) = 4.2$, $p < 0.005$. They appeared more in American Mainstream comics (3%) than any other types (all ps < 0.05). Swedish comics (.01%) used the least whole pages, differing from all but French *bande dessinée* (1%) and Japanese manga (<1%). Manga also trended as using fewer whole pages than Hong Kong manhua (2%, $p = 0.083$). American Indy comics used 1.4% whole pages.

Inset panels also differed significantly across countries, $F(5,54) = 2.5$, $p < 0.05$, but only because American Mainstream comics used substantially more inset panels (4%) than any other comics (all ~1% or less, all ps < 0.058), which in turn did not differ from each other.

Gutter space

Gutter distance was significantly different across types of panels, as indicated by main effects and an interaction between Gutter and Type (all Fs > 14, all ps < 0.001). Fewer normal gutters appeared in American Mainstream comics (52%) than all other types (all ps < 0.001), and were used less in Hong Kong manhua (84%) than all books (all ps < 0.052) except Swedish comics (89%). French *bande dessinée* (96%), Japanese manga (95%), and American Indy (93%) did not differ.

More variability in gutters appeared in American Mainstream comics than other types. American Mainstream comics (5%) used greater amounts of separated panels than Hong Kong manhua, Japanese manga and Swedish comics (all <1%, all ps < 0.054), but did not differ from French (3%) or American Indy (2%) books. American Mainstream comics also used far more overlapping panels (14%) than all other books (all ps < 0.001), which otherwise did not differ from each other (~2.5%). The absence of a gutter was used more in Hong Kong manhua (10%) and Swedish comics (9%) than all other types (all ps < 0.051), which otherwise did not differ (~2%).

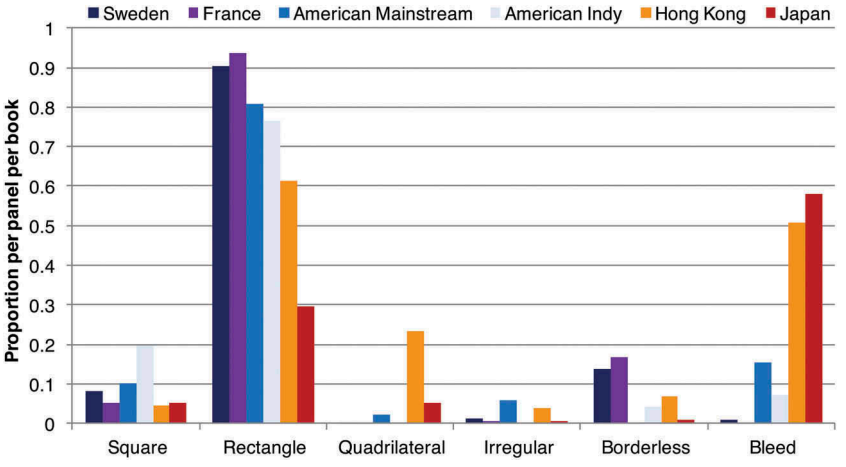

Figure 5. Different panel shapes and borders used in different types of comic pages.

Panel shapes

Different panel shapes were used significantly across types of panels (all Fs > 3.2, all *p*s < 0.05), except for triangular panels, which were used in very low proportions in all types of books (< 0.005%). As in Figure 5, rectangular panels were used more than any other type of panel shape, but were used less by Asian books than the other types of books (all *p*s < 0.079), which otherwise did not differ. Hong Kong manhua instead used substantially more quadrilateral panels and diagonal panels (4%), which almost never appeared in any other type of comic (all *p*s < 0.005). Square panels were used more by American Indy comics than all other types (all *p*s < 0.05), which otherwise did not differ. Both manhua and American Mainstream comics used more irregularly shaped panels than all other types (all *p*s < 0.05), in which they hardly appeared at all.

Although the absence of borders appeared more in French (16%) and Swedish (14%) panels than other types (<7%), the overall comparison across all types was not statistically significant ($p = 0.121$). However, Asian books used significantly more bleeding panels, where the content extended past the edge of the printed page, than all American and European comics (all *p*s < 0.001). American Mainstream books also trended in using more bleeds than French ($p = 0.071$) and Swedish comics ($p = 0.082$).

Cluster analysis

Finally, we used a *k*-means cluster analysis to assess the degree to which our selected books constituted groupings on the basis of the statistical regularity of their features. Our analysis used *k*-means of two separate cluster sizes: six clusters (based on the number of total groups selected) and three clusters (based on continent of origin).

Our analysis of six clusters showed that our chosen samples (i.e. countries) were not fully homogeneous, although they had fairly distinct trends (Figure 6(a)). For example, American Mainstream comics, Japanese manga and Hong Kong manhua largely constituted their own clusters (1, 3 and 6 respectively) with minimal overlap to groups other than each other. Meanwhile, Swedish, French and American Indy books were all

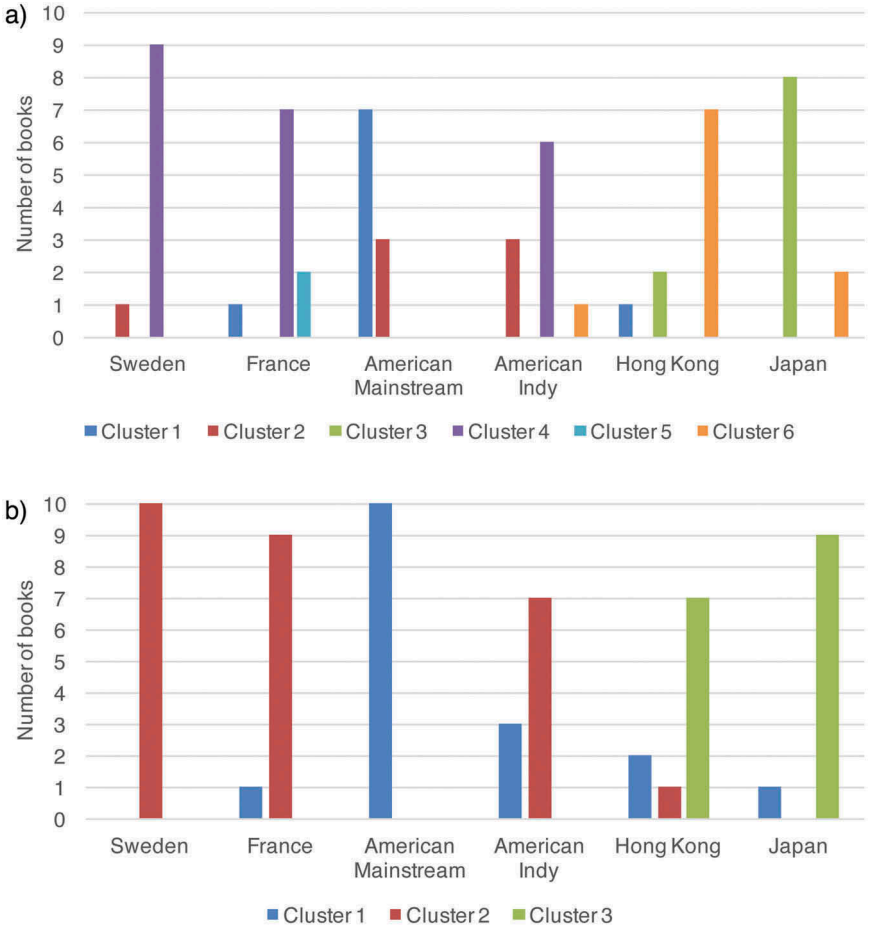

Figure 6. Results of clustering (*k*-means) of page layout features from comics from different cultures into (a) six clusters and (b) three clusters.

Table 2. Mean distances between clusters in a *k*-means analysis of six clusters (Figure 6(a)). Larger numbers mean greater dissimilarity between groups.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Cluster 1		0.643	0.909	0.78	1.01	0.578
Cluster 2			1.007	0.645	0.906	0.631
Cluster 3				1.028	1.309	0.634
Cluster 4					0.869	0.643
Cluster 5						0.968

grouped into a common cluster (4). Two French books comprised their own unique cluster (5). The mean distances between each cluster are provided in Table 2 – larger numbers suggesting greater dissimilarity from other clusters.

The three-cluster analysis yielded similar groupings, only more distinct (Figure 6(b)). Cluster 1 was the most diverse, consisting mostly of American Mainstream comics, with some American Indy comics, and those from other places. Cluster 2 consisted of European (Swedish, French) books and American Indy books, and Cluster 3 was

made up wholly of Japanese manga and Hong Kong manhua. Cluster 1 was maximally different from Cluster 3 with a mean distance of 0.718, and somewhat less than Cluster 2 (0.602). Clusters 2 and 3 were the most dissimilar, with a mean distance of 0.872.

Discussion

This study explored the properties of external compositional structure (page layouts) across several different cultures' comics. Although we consider this to be a preliminary investigation, we have found several distinct results about the structure of pages from different types comics. Below, we highlight these characteristics as emerging from our particular sampling, and further discuss their implications on theories of the structure and cognition of page layouts.

Our first finding was that, although the rough average of panels from all cultures hovered between five and seven panels per page, books from Europe used close to two more panels per page than American and Asian comics. We believe that some influence of this difference may come from formatting. European books, like *bande dessinée*, typically appear in 'album' format with larger physical pages than those from America or Asia. This extra space may thus result in the levity to include extra panels, without worrying about compromising the visibility of content being too small (Lefèvre 2000). Of course, format itself does not mandate panel density – more panels could simply fill a smaller page size. Thus, this implies that panels have an optimal relative sizing on a printed page, such that a larger page would afford more of them. Additional research could thus examine absolute sizing (actual physical size of panels on a printed page) and relative sizing (proportional size of a panel on a page).

Overall, our sample of different types of comics was found to exhibit fairly identifiable properties of page layout. This was suggested particularly by our cluster analysis, which showed that distinguishable groupings emerge from the aggregated properties of our selected sample works. While the resulting clusters were not fully homogeneous, in some cases, they aligned with noticeable cultural differences, likely motivated by particular properties of layout (summarised in Table 3). For example, European books (French, Swedish) used more horizontal staggering and borderless panels than other comics, and with square or rectangular panels in a Z-path grid. In contrast, Asian books (Japanese, Hong Kong) were characterised by vertical directions in blockage and more moderate use of pure grids, along with fewer rectangular panels and high proportions of bleeds. American books differed between the Mainstream and Indy genres though. Indy comics used more horizontal staggering and rectangular or square panels, more akin to European comics, a similarity suggested by both cluster analyses. Although Mainstream books used pure grids, this was supplemented with vertically stacked widescreen panels, splash pages, and inset panels, more variable gutter distances (overlap, separation), and some irregular panel shapes with some bleeds.

The overall variability between layouts in different types of books in our sample implies that there may be conventionalisation in features of ECS with patterned and recognisable traits across works. That is, certain layouts may be associated with certain types of comics. Future work can no doubt expand analyses beyond the limited selection of comics examined here. For example, Asian books were also characterised by bleeds, compared with all other types. Bleeding and borderless panels have been said

Table 3. Summarised characteristics of external compositional structure of comics of different types, given the empirical findings of this corpus.

Type	Panel Arrangements	Gutter properties	Panel shapes
Swedish comics	More panels per page Greater amounts of Z-path with pure grids and horizontal staggering	Higher rates of lack of gutters	Square and rectangular panels More borderless panels
French *bande dessinée*	More panels per page Increased Z-path, mostly horizontal staggering, but fewer pure grids	Normal gutters	Rectangular panels More borderless panels
Hong Kong manhua	More vertical directions in blockage, moderate use of pure grids	Increasing use of lack of gutters	Fewer rectangular panels, more variable shapes (diagonal, quadrilateral, and irregular) More bleeds
Japan shonen manga	More vertical directions in blockage, moderate use of pure grids	Normal gutters	Fewer rectangular panels More bleeds
American Indy comics	Moderate use of pure grids and greater use of horizontal staggering	Normal gutters	Rectangular and square panels
American Mainstream comics	Z-path using pure grids without staggering Vertical directions focused in whole rows (widescreen) Whole splash pages and inset panels	More variable gutters: less normal gutter, more separation and overlap	Rectangular panels but higher rate of irregular panel shapes Moderate amount of bleeds

to be particularly characteristic of shojo manga (Takahashi 2008; Schodt 1983). However, we find bleeds here to be substantially used in shonen manga. Whether there are differences between these genres would make for a good follow up study, as would more nuanced comparisons within cultures (across genres, publishers, time periods, etc.) or across cultures.

Another difference between layouts is the directionality between panels. Because written text in alphabetic languages uses a Z-path, it has been assumed that the default navigation for reading a comic page also follows this lateral then diagonal-down route. However, Asian layouts consistently varied from this pattern, especially manhua from Hong Kong. While both manga and manhua used a fair amount of grids (~30%), they also used more vertical arrangements embedded in blockage. American Mainstream comics also showed frequent downward panel relations, due to successive use of panels spanning a whole row. This panelling reflects the movement towards 'widescreen' layouts, which has emergent since the 1990s in American superhero comics (Pederson and Cohn 2016). Thus, American Mainstream comics did not use verticality embedded within layouts, but rather used panels as a whole row – a Z-path that removes the internal laterality.

This difference in the context of using vertical directionality may be one reason why our clustering analysis rendered Asian books (cluster 3) as mostly distinct from American Mainstream (cluster 1) comics, despite sharing in greater proportions of verticality. Indeed, a more detailed look at our clustering results reveal similar means for cluster centres for vertical directionality (cluster 1: 0.214; cluster 3: 0.218) which both far exceed the cluster containing European/American Indy comics (cluster 2:

0.069). However, the cluster containing Asian books used more blockage (cluster 1: 0.125; cluster 2: 0.063; cluster 3: 0.246) while the cluster largely constituting American Mainstream comics had more panels as a whole row (cluster 1: 0.311; cluster 2: 0.134; cluster 3: 0.228).

Because Asian comic pages in our analysis use more verticality and columnar arrangements embedded in layouts than American or European books, it may reflect an influence of the directionality of the writing systems. Written Chinese and Japanese both use a columnar top-to-bottom directionality, although they can also be written laterally in a Z-path. The higher proportion of vertical arrangements in page layouts thus may a subtle influence of the written language on the structure of their visual language. This would be consistent with other findings that the direction of writing systems influences several cognitive factors. Particularly pertinent to spatially arranged visual narratives is the preference for using orientations similar to writing systems in depicting temporal relationships (Chan and Bergen 2005; Tversky, Kugelmass, and Winter 1991) and determining temporal order of images (Fuhrman and Boroditsky 2010), as well as for perceptually scanning arrays (Padakannaya et al. 2002).

Nevertheless, despite the preference of their writing systems as a whole to use vertical columns, Asian layouts are still dominated by the lateral Z-path. Indeed, other comics in these cultures do use a straight vertical layout, such as daily comic strips. Thus, in the case of *pages*, Asian layouts have maintained the conventionalised navigational path consistent with American and European books, although imbued with additional verticality, likely influenced from the verticality of their writing systems.

Differences also arise in types of arrangements. For example, the influence of vertical writing direction may motivate the more frequent use of blockage in Asian books than American or European books. Meanwhile, American Mainstream books use more panels spanning a whole row. In addition, European pages appear to use layouts more reflective of the Z-path, but especially with higher proportions of horizontal staggering. That is, they use rows of panels, but do not feel compelled to lock them into a pure grid. This trend appears in American Indy comics as well, which largely clustered with European comics. Previous analyses have shown that horizontal staggering appeared prevalently in American superhero comics in the 1940s, but significantly decreased over the past 80 years (Pederson and Cohn 2016).

The greater proportion of horizontal staggering in European books (and, somewhat, American Indy comics) implies greater salience of the row as a unit. Hierarchic theories of page layouts often emphasise the embedding of vertical and horizontal groupings of panels (Cohn 2013a; Tanaka et al. 2007; Bateman et al. 2016). The salience of rows would thus place additional focus on the horizontal constituents in European and American Indy comics. This focus could also possibly be why European theories of page layout place greater emphasis on 'the strip' – i.e. rows – as a unit within page layout (Groensteen 2007; Chavanne 2015). For example, Chavanne (2015) characterises patterns of panel relations involved in vertical and horizontal arrangements (grids, blockage). However, these arrangements are largely constrained to relations within individual strips/rows, without a way to link them together into a necessary broader hierarchic structure (as in Cohn 2013a, Tanaka et al. 2007, etc.). Such characterisation may be a result of increased familiarity with European layouts that emphasise such

rows in a patterned way, with less consideration of more culturally variable layouts with their own systematic tendencies.

The findings of greater proportions of horizontal staggering in European books also has implications for cognition. Insofar as page layouts are produced by creators and comprehended by readers, they must involve cognitive structures in the minds of those individuals. The variation across cultures would thus be a reflection of systematic patterning for various creators within a culture. This variation could then become habituated by readers, possibly manifesting as preferences for structures in reading experience.

For example, Cohn and Campbell (2015) showed that the vertical height of a 'blocking' panel modulates whether readers will choose a horizontal Z-path (treating that panel as a vertical stagger) or a vertical path (treating that panel as blockage). Given that Hong Kong manhua page layouts appear to use more vertical staggering and blockage than those of other cultures, might readers of these books have a higher threshold of acceptance for vertical staggering as *not* indicative of blockage? Or, conversely, might readers of other types of comics have more sensitivity to treating vertical staggering as potentially indicative of blockage? Such concerns are important for the ease of cross-cultural reading and translating of comics and in testing the psychology of features of page layouts.

In addition, such cultural findings have direct implications for cognitive theories. Hierarchic theories of layout posit that panels can be grouped into horizontal and vertical constituents, tempered by various constraints related to panel orientations (Cohn 2013a, 2013b). Such hierarchic structures have also been reliably extracted in corpus analysis by computational algorithms (Cao, Chan, and Lau 2012; Tanaka et al. 2007). However, these underlying hierarchic structures do not differentiate between Z-paths using a pure grid and horizontal staggering, which both concatenate horizontally ordered panels into vertically stacked rows (Figure 7). However, cultures have patterned regularities for these types of arrangements (Europe: horizontal staggering, USA.: pure grid). Our current data are interesting in that this implies that authors from these cultures are encoding something in memory beyond these hierarchic groupings alone, which motivates them to use such structures in systematic ways. A cognitive theory thus needs to incorporate some specification of surface arrangement features like these into a model of ECS, in addition to the broader constituent structures.

In sum, our study provides preliminary evidence for the empirical study of the external compositional structure of pages in comics from various cultures. We found that layouts differ in systematic ways, suggesting patterned characteristics of layout which may entwine with influences from other habits of reading, such as writing systems. These patterns also hint at a need for cognitive theories of page layout to take into account cross-cultural findings. Such results thus highlight the benefits of a multifaceted approach to visual language structure that balances theoretical modelling, psychological experimentation, and corpus analysis.

Disclosure statement

No potential conflict of interest was reported by the authors.

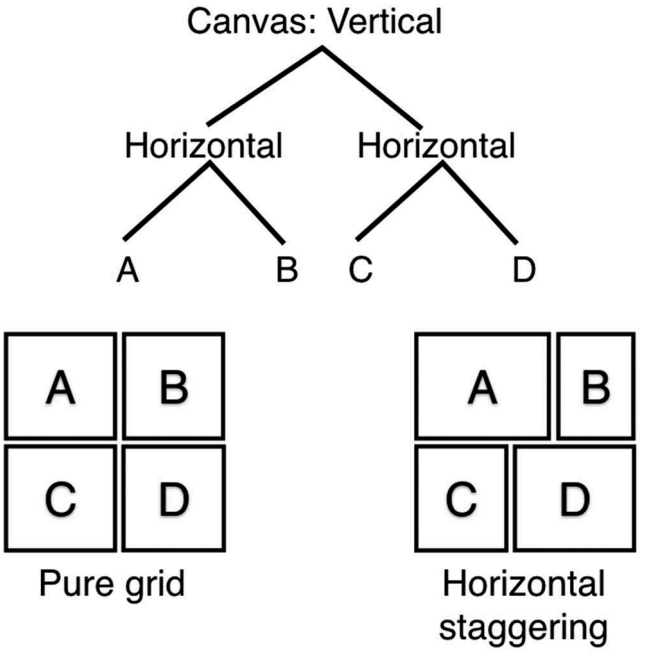

Figure 7. The same underlying hierarchic structure appears for both pure grids and horizontal staggering.

Notes on contributors

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Appendix. Works analysed

American Mainstream

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